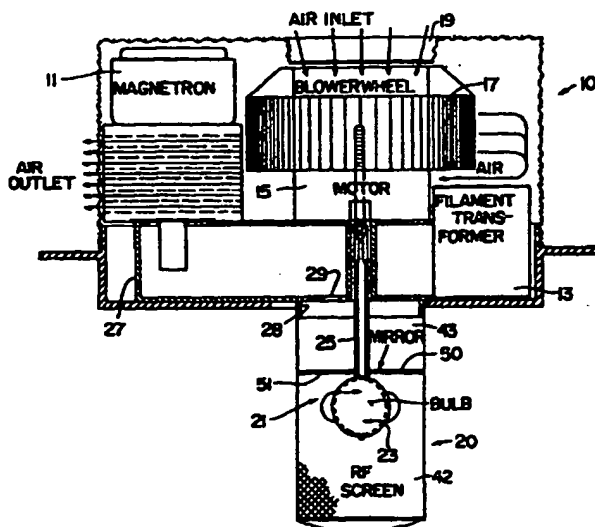




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: <b>PCT/US96/18562</b> (22) International Filing Date: <b>3 December 1996 (03.12.96)</b> (30) Priority Data: <b>08/592,474</b> <b>26 January 1996 (26.01.96)</b> <b>US</b> (71) Applicant (for all designated States except US): <b>FUSION LIGHTING, INC. [US/US]; 7524 Standish Place, Rockville, MD 20855 (US).</b> (72) Inventors; and (75) Inventors/Applicants (for US only): <b>TURNER, Brian [US/US]; 9087 Dawn Court, Myersville, MD 21773 (US). URY, Michael [US/US]; 6518 E. Halbert Road, Bethesda, MD 20817 (US).</b> (74) Agent: <b>EDELL, Ira, C.; Epstein, Edell &amp; Retzer, Suite 400, 1901 Research Boulevard, Rockville, MD 20850 (US).</b>	(81) Designated States: <b>AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b>  Published <i>With international search report.</i>	

(54) Title: MICROWAVE CONTAINER SCREENS FOR ELECTRODELESS LAMPS



## (57) Abstract

A microwave electrodeless lamp (10) includes an improved screen unit (20) having a mesh section (42) and a solid section (43) with an internal reflector (50) to reflect light emitted from a bulb (21). Light emitted from the bulb (21) is prevented from entering the solid portion (43) of the screen unit (20). The solid section (43) further includes multiple compliant fingers (45) therein which engage with the periphery of a flange (28) on waveguide unit (27) by means of a hose clamp (60). Mesh sections having different configurations can be used to provide different illumination patterns. Also, the material of the mesh section (42) may be of the solid material type.

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## Microwave Container Screens for Electrodeless Lamps

### BACKGROUND OF THE INVENTION

#### Technical Field:

The present invention pertains generally to microwave powered electrodeless lamps and, more specifically, to improvements in screen structures used in such lamps to block escape of microwave energy while permitting transmission of light.

#### Discussion of the Prior Art:

Lamps utilizing radio frequency (RF) energy to excite electrodeless bulbs are well known. Examples of such lamps may be found in U.S. Patent Nos. 4,954,755 (Lynch et al), 5,227,698 (Simpson et al), 5,334,913 (Ury et al) and 5,404,076 (Dolan et al). The disclosures in all of these patents are expressly incorporated herein. In lamps of this type microwave energy is coupled from a magnetron or other RF source to the lamp bulb via a coupling circuit including a waveguide and a quasi-resonant cavity typically defined, at least in part, by a screen unit. The waveguide functions as an impedance matching device from the source to the cavity.

Prior art screen structures used in microwave powered lamps are disclosed in numerous prior patents as represented by the above-mentioned Lynch et al, Simpson et al, Ury et al and Dolan et al patents, and in European Patent Specification 0 153 745 (Yoshizawa et al). Such screens typically surround a bulb envelope and serve to allow optical radiation from the bulb to escape while forming

a conductive enclosure blocking escape of RF energy. Screen design has generally involved an inherent compromise between these factors. Specifically, screens having very low optical loss tend to permit escape of undesirably large amounts of RF radiation. On the other hand, elimination of RF radiation generally incurs the penalty of diminishing optical transmission through the screen.

In addition, in many prior art screens, a metallic ring is attached to the screen base so that the ring can be fastened to the waveguide. The inclusion of the ring as part of the screen adds significant expense to screen fabrication.

Further, in producing a lamp product line, it is often desirable to minimize the cost involved in permitting different optical configurations for different models of lamps. In other words, a manufacturer would prefer to utilize as many common components as possible from model to model. Where components must be changed, ideally they are inexpensive components. It is advantageous, therefore, to provide a screen design that is inexpensive and configured so that the expensive components of a lamp assembly can remain common to various lamp models having different optical characteristics.

### **OBJECTS AND SUMMARY OF THE INVENTION**

Accordingly, it is an object of the present invention to provide an inexpensive screen enclosure for microwave powered electrodeless lamps wherein optical transmission and radio frequency blockage are optimized.

It is another object of the present invention to provide a screen enclosure for a microwave powered lamp that is inexpensive to fabricate yet easily and inexpensively secured to a waveguide.

In accordance with the present invention, a screen structure for a microwave powered electrodeless lamp includes a metal mesh section and a metal solid section. The mesh section is transmissive to light and non-transmissive to microwave energy at the operating frequency. The solid section is non-transmissive to both light and the microwave energy. In this regard, the term "solid" as used herein is intended to distinguish from the mesh section and connotes the absence of gaps or breaks in the structure.

In the preferred embodiment the mesh section has a right cylindrical configuration with a mesh end cap at one end, and the solid section is configured as a right cylindrical section of like diameter extending coaxially from the opposite end of the mesh section. A reflector, in the form of an electrically non-conductive circular disk, has its annular edge secured at the annular juncture between the mesh and the solid sections, and is disposed coaxially with both of these sections with its reflective surface facing into the mesh section. The reflector thus defines an optically isolated light transmission chamber within the microwave cavity. An electrodeless bulb has its discharge envelope disposed within the light transmitting cavity surrounded by the mesh section. The reflector is centrally apertured to permit passage of the bulb stem through the space bounded by the solid section of the screen unit.

In its preferred form the screen unit is fabricated from two members. A first member comprises a single thin rectangular sheet of metal, preferably stainless steel, that is etched or otherwise formed to provide the mesh and solid sections therein. The mesh section is bounded along its exterior edges by a narrow solid border, formed as a continuance of the solid section, to facilitate assembly. The second member is a circular metal mesh piece circumferentially bounded by a narrow solid border. In assembling the two pieces to form the screen unit, the rectangular sheet is first rolled into a right circular cylinder such that opposite edges of the sheet are joined. These edges, including the solid border portions of the mesh section, are sealed together by suitable adhesive, welding, or other bonding technique. The second member is then secured as an end cap to the mesh section of the cylinder by adhering together the solid borders at abutting edges of the two members.

The rectangular sheet comprising the first member preferably has a plurality of spaced slots defined inwardly from the edge of the sheet opposite the mesh section. These slots define "fingers" therebetween, the fingers being sufficiently compliant to allow for a small deformation of the edge of the screen unit that attaches to the waveguide. Specifically, these fingers are defined along the annular proximal edge of the screen unit that attaches to the waveguide. An annular clamp,

similar to a hose clamp, is used to secure the fingers in place about the waveguide opening.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, particularly when taken in conjunction with the accompanying drawings wherein like reference numerals in the various figures are utilized to designate like components.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a partially diagrammatic view in longitudinal section of a lamp assembly employing a screen unit according to the principles of the present invention.

Fig. 2 is a side view in elevation of the screen unit used in the assembly of Fig. 1.

Fig. 3 is an exploded view in perspective of a portion of the screen unit of Fig. 1 showing the manner in which it attaches to the lamp assembly.

Fig. 4 is a broken detailed view in perspective of a portion of the screen assembly of Fig. 3 showing a reflector secured in the screen assembly.

Fig. 5 is a top view in plan of an etched metal sheet used to form the screen assembly of Fig. 2.

Fig. 6 is a side view in elevation of the lamp assembly of Fig. 1 shown with a reflector module attached thereto.

Fig. 7 is a side view in elevation of an alternative configuration of the screen assembly of the present invention.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring specifically to Fig. 1, a lamp assembly using the screen unit of the present invention includes a lamp module 10 comprising a housing for a magnetron 11 or other microwave source, a filament transformer 13 supplying filament current to the magnetron 11, and a motor 15 for rotating a bulb and for driving a cooling fan in the form of blower wheel 17. An air inlet 19 for fan 17 is defined in one end of the housing.

A screen assembly 20 defines a microwave cavity wherein a bulb 21 is disposed. Bulb 21 includes a generally spherical discharge envelope 23 supported at the end of an elongate cylindrical stem 25. Stem 25 is secured to a drive shaft 27 of a motor 15 to permit the bulb 21 to be rotated about the longitudinal axis of its stem 25. Bulb 21 has a fill material contained in its discharge envelope 23 such as, for example, the material described in the above-referenced Dolan et al patent. The bulb is made of quartz or other suitable material.

Microwave energy generated by magnetron 11 is fed by a waveguide 27 to a coupling slot 29 providing ingress to the microwave cavity defined by screen unit 20.

Referring to Figs. 2 - 5, the screen unit 20 of the preferred embodiment is made from two members, namely a right cylindrical member 30 and an end cap 40. Each of these two members is formed as a respective one-piece unit. Specifically, cylindrical member 30 is formed from a single sheet 41 (see Fig. 5) of metal that has been etched to provide a metal mesh section 42 and a metal solid section 43. Preferably, sheet 41 is a stainless steel sheet having a thickness between 0.003 and 0.005 inches. Mesh section 42 is etched through the sheet, the etching pattern preferably being controlled by computer so that virtually any location of the mesh section or sections and any pattern and size of the interstices of the mesh can be provided. The size and pattern of the interstices are selected to minimize transmission of RF energy through the conductive mesh. In the preferred embodiment mesh section 42 and solid section 43 are formed in sheet 41 as adjacent rectangular sections meeting at a straight line juncture corresponding to the abutting inboard edges of these two sections. The three outer edges of mesh section 42 are bounded by a very narrow solid metal border or strip 44 formed as a continuance of solid metal section 43. The longer outer edge of solid section 43 has multiple slots etched therethrough and extending perpendicular to that edge toward mesh section 42. These slots define multiple finger-like members 45 which, because of the thinness of the material of sheet 41 and the spacing of the slots, are individually compliant to facilitate attachment of the screen unit to the assembly in the manner described below.

As seen in Figs. 2 and 3, during assembly sheet 41 is rolled into a right circular cylinder such that mesh and solid sections 42 and 43 form respective adjacent cylindrical sections for the resulting screen unit 20. In order to maintain the final cylindrical form of the rolled sheet, opposite edges of the sheet are slightly overlapped, i.e., by the width of border 44, and then secured together by any suitable means such as adhesive, welding, etc. In the resulting cylinder 30, the end comprising fingers 45 defined in solid section 43 is referred to herein as the proximal end of the cylinder; the opposite end, bounded by the annular portion of border 44 of mesh section 42, is referred to herein as the distal end.

In an exemplary embodiment of the present invention, a stainless steel sheet 41 is rectangular in shape and has a thickness of 0.102 mm. The length and width of the sheet are 237.13 mm and 125.73 mm respectively. The width of solid section 43 is 41.91 mm, and the width of mesh section 42 is 83.82 mm. Edge border 44 is 1.52 mm wide. Fingers 45 are sixteen in number, extend 10.0 mm into solid section 43 from the edge of sheet 41, are separated by 1.3 mm wide slots and are 13.4 mm wide. It is to be understood that these dimensions are provided by way of example only and are not in any way limiting on the scope of the invention.

End member 40 is a substantially circular mesh member formed from the same material and by the same process as cylindrical member 30. The mesh end member 40 is circumferentially bounded by a solid border 46. Border 46 and the annular portion of border 44 of cylinder 30 are joined together by crimping, welding or other suitable technique to provide a mesh closure at the distal end of the cylinder.

As best illustrated in Figs. 3 and 4, a reflector 50 takes the form of a circular disk having an outside diameter substantially equal to the inside diameter of cylindrical member 30. Reflector 50 is typically made from fused silica and has at least one surface 51 with an optically reflective metal oxide coating which does not absorb microwave energy. A small centrally located aperture 53 is defined in disk 50 and is of sufficient size to permit stem 25 of the bulb to pass therethrough. Reflector 50 is positioned coaxially within the microwave cavity at a location corresponding to the annular juncture of mesh section 42 and solid section 43. In



this manner reflector 50 effectively defines an optically isolated light transmission chamber by optically closing off the proximal end of mesh section 42 from the remainder of the microwave cavity without affecting the quasi-resonant characteristics of the overall cavity at the operating microwave frequency. Attachment of reflector 50 to the cylinder is achieved by placing high temperature ceramic cement (e.g., Saurereisin) at plural locations around the edges of the disk where it contacts screen unit 20.

The screen unit is secured to the lamp assembly 10 (see Figs. 1 and 3) by disposing fingers 45 circumferentially about an annular flange 28 extending from the assembly housing. The compliance inherent in the finger structure facilitates this placement. An annular hose clamp 60 (Fig. 3) may then be placed circumferentially about the fingers and then tightened by radial contraction to secure the fingers to the flange 28. Coupling slot 29 from the waveguide is located radially inward of flange 28 so that the microwave energy from magnetron 11 can be delivered into the microwave cavity defined by screen unit 20.

In the assembled unit the bulb discharge envelope 23 is disposed in the optically isolated optical transmission chamber of the microwave cavity defined circumferentially by cylindrical mesh section 42 and at its ends by reflector 50 and end cap 40. Bulb stem 25 extends through aperture 53 in reflector 50 into the opaque chamber bounded by solid section 43, and then through a suitably provided bore in the lamp assembly housing where the stem is engaged by a rotatable drive shaft of motor 15 to permit rotation of the bulb about the stem axis. As is conventional, one of the effects produced by rotation of the bulb in this manner is the cooling of the bulb discharge envelope 23 in the microwave cavity.

Microwave energy entering the cavity defined by screen unit 20 via coupling slot 29 excites the fill in discharge envelope 23 resulting in light energy being emitted from the envelope. Reflective surface 51 prevents the light from entering the region of the microwave cavity bounded by solid section 43 of the cylindrical member 30. Instead, light impinging upon surface 51 is reflected out of the cavity through the interstices in mesh section 42 and end cap 40. Reflector 50, and in particular reflective surface 51, may be contoured as desired (e.g., concave, convex, etc.) to

reflect light in preferential directions through the mesh. Clearly, substantially all of the light energy is prevented from passing into the region bounded by the solid section of the cylinder, thereby permitting the light to be most efficiently transmitted out through the interstices of the mesh material. Since the portions of the microwave cavity boundary wall through which light transmission is not desired are solid, the overall RF leakage through the screen unit is greatly reduced from that of an all mesh screen unit.

The lamp assembly described above may be utilized with an external reflector for focusing the light emitted through screen unit 20. Referring to Fig. 6, the assembly of Figs. 1 - 5 is shown fitted with a substantially parabolic reflector 61 mounted on the lamp assembly by means of a bracket 62. Reflector 61 is positioned about mesh screen section 42 such that the bulb envelope 23 is disposed at or near the reflector focal point. The narrow end of reflector 61 is substantially co-planar with internal reflector 50 of the microwave cavity. The wide end of the reflector may be covered with a suitable glass cover.

As noted above, the cylindrical member of the screen unit is preferably fabricated by selectively etching the desired mesh pattern in a sheet of metal. It will be appreciated that the mesh pattern can easily take any shape consistent with the desired light transmission pattern for the lamp assembly. An example of another cylindrical member for a screen unit 70 formed in this manner is illustrated in Fig. 7. In this unit there are two solid metal sections, namely proximal cylindrical solid section 71, in which compliant attachment fingers 75 are formed, and a distal cylindrical solid section 73. Intermediate the two solid sections is a cylindrical mesh section 72. A proximate reflector 75 is secured at the juncture between proximal solid section 71 and mesh section 72 and has a domed convex reflective surface facing the optical transmission chamber in which the bulb discharge envelope 23 is located. A distal reflector 76 is secured at the juncture between distal solid section 73 and mesh section 72. Distal reflector 76 has a generally conical reflective surface converging toward the discharge envelope 23. Accordingly, all light emanating from the assembly is directed through the mesh section 72 of the screen unit closed by reflectors at its ends, and no mesh end cap is required. Such cap (not

illustrated) therefore may be solid and made from the same material as solid sections 71 and 73 of the cylinder.

An important advantage of the present invention is that it permits the entire assembly of Fig. 1 to be used interchangeably with screens of different configuration to produce a variety of illumination patterns. More specifically, and by way of example only, the screen unit in Figs. 2 - 5 can be replaced with the unit of Fig. 7. The advantage of this is that the screen is extremely inexpensive to manufacture as compared to the other components of the assembly.

It will be appreciated, therefore, that the cylindrical member 30 can be etched or otherwise formed with any combination of mesh and solid sections from one sheet of metal. By appropriately locating one or more reflectors in the resulting microwave cavity, the optically transmissive chamber of the cavity can be isolated from the remainder of the cavity, thereby minimizing RF leakage while optimizing light transmission.

Although the screen unit for the preferred embodiments illustrated herein includes a substantially cylindrical member, it will be appreciated that the microwave cavity, in some instances, need not be cylindrical. In this regard, the same techniques described hereinabove may be utilized to provide screen units having rectangular, polygonal, oval, or other transverse cross-sections.

It will also be appreciated that the resulting screen unit of the present invention is very inexpensive to manufacture. Accordingly, if different optical configurations are required for a product line, the same overall assembly 10 may be utilized with a different screen unit in which the mesh and solid sections are oriented to yield the desired emitted light pattern.

The present invention also eliminates the requirement of fabricating a screen with an attached metal ring to secure the screen to the lamp assembly. The compliant fingers provided in the screen unit of the present invention, in combination with the hose clamp arrangement, obviates the need for the prior art permanent ring (an expensive step in screen fabrication) and allows for rapid, easy attachment of the screen unit to the lamp assembly.

The screen unit of the present invention allows for a multitude of solutions for moving and removing heat from the bulb and optics of the system. For example, by pressurizing the volume at the proximal end of the screen unit (i.e., defined by the reflector, the solid portion of the screen unit and the waveguide), one may introduce a flow of air to the bulb for cooling purposes. One may also derive a alternative ways of utilizing this enclosed volume as a plenum to deliver air to parts requiring cooling. Still further, the continuous portions of the screen may be treated to absorb and radiate efficiently, allowing for heat transfer from the optics internal to the cavity to the outside environment.

In order to enhance the optical and/or microwave characteristics of the lamp, it is possible to coat or plate the mesh and the solid portions of the screen unit. These same coatings may be difficult or cost prohibitive if applied to the waveguide.

From the foregoing description it will be appreciated that the invention makes available a novel screen unit for electrodeless lamps wherein mesh and solid sections may be defined in a single member used to form the body of a microwave cavity, and wherein a reflector can be disposed at the juncture between the solid and mesh sections to optically isolate those sections to achieve improved light transmission while reducing microwave energy leakage from the cavity.

Having described preferred embodiments of a new and improved microwave containment screen for electrodeless discharge lamps, it is believed that other modifications, variations and changes will be suggested to persons skilled in the art in view of the teachings set forth herein. Accordingly, it is to be understood that all such variations, modifications and changes are believed to fall within the scope of the present invention as defined by the appended claims.

**What is Claimed is:**

**1. A microwave powered lamp comprising:**

**a source of microwave energy;**

**a microwave cavity having at least one peripheral boundary wall with a solid section substantially impervious to light and to said microwave energy, and a mesh section transmissive to light and adapted to retain said microwave energy;**

**an electrically non-conductive light reflector mounted within said cavity to subdivide said cavity into first and second chambers, said first chamber including said solid section of said peripheral boundary wall, said second section including at least part of said mesh section of said peripheral boundary wall, wherein said reflector is oriented to reflect light into said second chamber and to block light transmission between said chambers;**

**a discharge envelope containing material excitable by said microwave energy to the point of emitting light, said discharge envelope being maintained in said second chamber such that light emitted therefrom is transmitted through said mesh section both directly from said envelope and as reflected from said reflector; and**

**coupling means directing said microwave energy from said source into said cavity to excite said material in said discharge envelope.**

**2. The lamp of claim 1 further comprising a drive motor for rotating said discharge envelope, wherein said discharge envelope is supported on a stem extending through said reflector, into and through said first chamber, and into rotatable engagement with said motor.**

**3. The lamp of claim 1 wherein said coupling means comprises a waveguide unit and a coupling slot disposed in a housing, said housing having a flange projecting outward from the housing and circumscribing said coupling slot;**

**wherein said microwave cavity is secured to said housing at said flange by plural compliant circumferentially spaced fingers projecting from said solid section and disposed about said flange, and a hose clamp compressing said fingers against said flange.**

4. The lamp of claim 1 wherein said peripheral boundary wall is a one-piece sheet of metal through which said mesh section is defined over a prescribed area.

5. The lamp of claim 4 wherein said mesh section comprises multiple interstitial openings etched through said sheet.

6. The lamp of claim 5 wherein said solid and mesh sections comprise adjacent cylindrical sections, wherein said coupling means communicates directly with said first chamber of said cavity to direct said microwave energy into said first chamber.

7. The lamp of claim 6 wherein said mesh section is bounded by a narrow solid metal border except at its edge adjacent said solid section, said border comprising a continuance of the solid section, and wherein said sheet is rolled about an axis to form said peripheral boundary wall as a cylinder with said border along opposite edges of said sheet in overlapping and joined relation.

8. A microwave powered lamp comprising:  
a microwave cavity having a boundary wall formed from a single metal sheet having a solid section and a mesh section defined therein;  
coupling means for delivering microwave energy to said cavity;  
a discharge envelope mounted in said cavity and containing fill material responsive to excitation by microwave energy for emitting light; and  
an electrically non-conductive reflector mounted in said cavity for defining an optically isolated light-transmitting chamber in said cavity wherein said reflector is positioned to reflect light from said envelope into said chamber and out through said mesh section.

9. The lamp of claim 8 wherein said mesh and solid sections meet at a juncture, and wherein said reflector is secured at said juncture to define said light-transmitting chamber between said mesh section and said reflector, leaving a

remainder of said cavity bounded by the optically non-transmissive solid section and said reflector.

10. The lamp of claim 8 wherein said sheet has multiple compliant fingers defined in spaced relation along one edge thereof for securing said cavity to said coupling means.

11. A method for improving the optical transmission of light from a microwave powered electrodeless lamp of the type having a discharge envelope disposed in a microwave cavity and containing fill material responsive to microwave energy for emitting light, said method comprising the steps of:

(a) forming a mesh pattern through part of a thin metal sheet to define adjacent mesh and solid sections in said sheet with a juncture between said sections;

(b) securing opposite edges of said sheet to one another to form a peripheral enclosure for said cavity;

(c) securing an electrically non-conductive light reflector in said cavity to reflect light into an optical transmission chamber bounded at least in part by said reflector and said mesh section; and

(d) disposing said discharge envelope in said optical transmission chamber.

12. The method of claim 11 wherein step (a) includes etching said mesh pattern through said sheet.

13. The method of claim 11 further comprising the steps of:

(e) securing said cavity to a waveguide assembly of said lamp by forming multiple compliant fingers along one edge of said sheet as part of step (a);

(f) disposing the compliant fingers about a continuous flange on said waveguide assembly; and

(g) radially constricting said fingers about said flange with a clamp.

14. The method of claim 11 further comprising the step of:

(e) securing said cavity to a waveguide assembly of said lamp.

15. The method of claim 14 further comprising the steps of:

(h) forming in a second thin metal sheet a second mesh pattern different from the mesh pattern formed in step (a);

(i) securing opposite edges of said second metal sheet to one another to form a peripheral enclosure defining a second cavity;

(j) securing a second electrically non-conductive light reflector in said second cavity to reflect light into a second optical transmission chamber bounded at least in part by said second reflector and second mesh section;

(k) disposing a discharge envelope in said second optical transmission chamber;

(l) removing from said waveguide assembly the cavity secured thereto in step (a); and

(m) securing said second cavity to said waveguide assembly.



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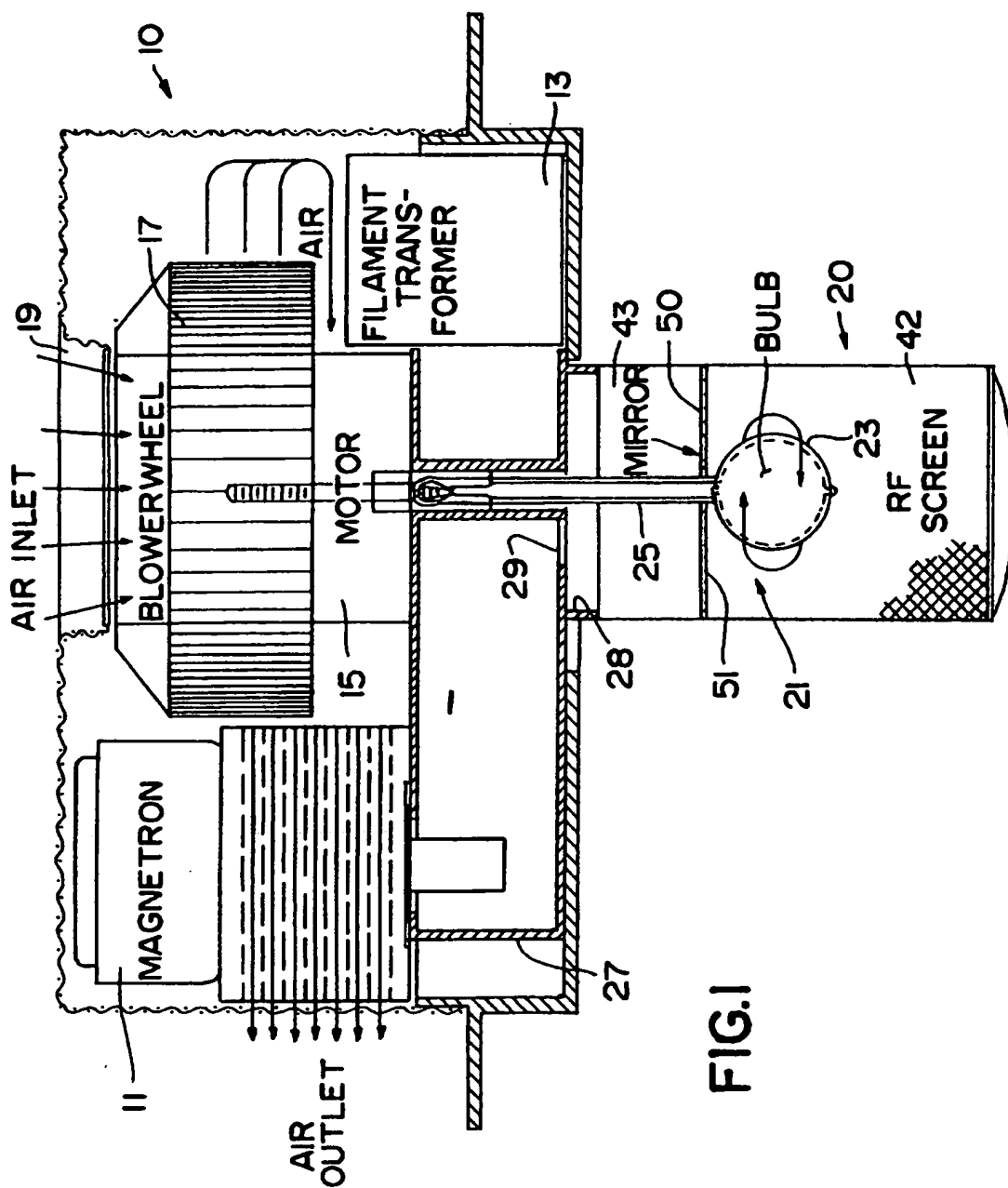
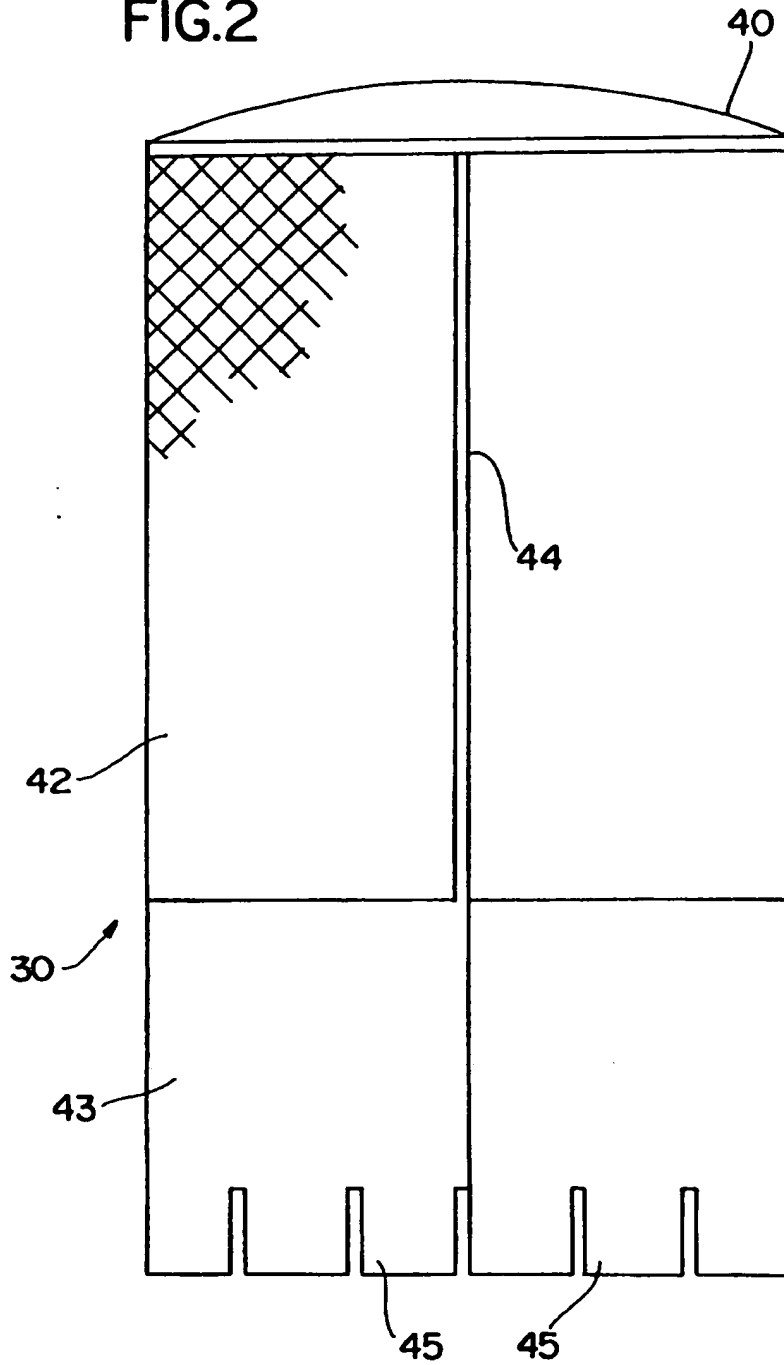


FIG. 1

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FIG.2



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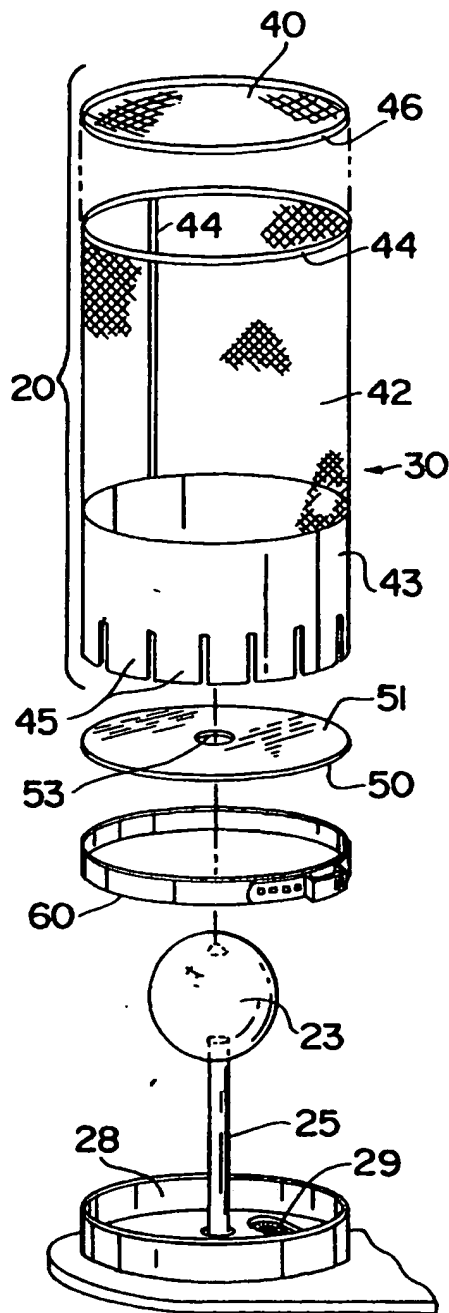


FIG. 3

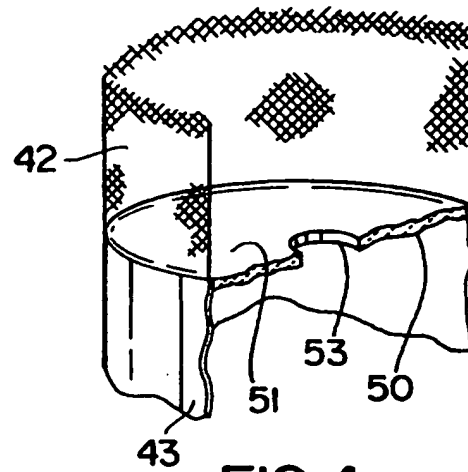


FIG. 4

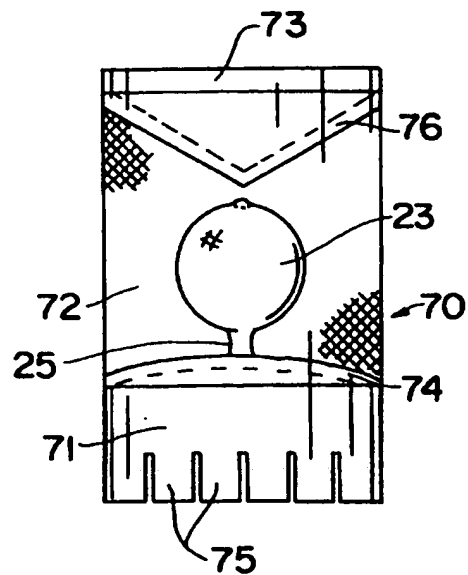


FIG. 7

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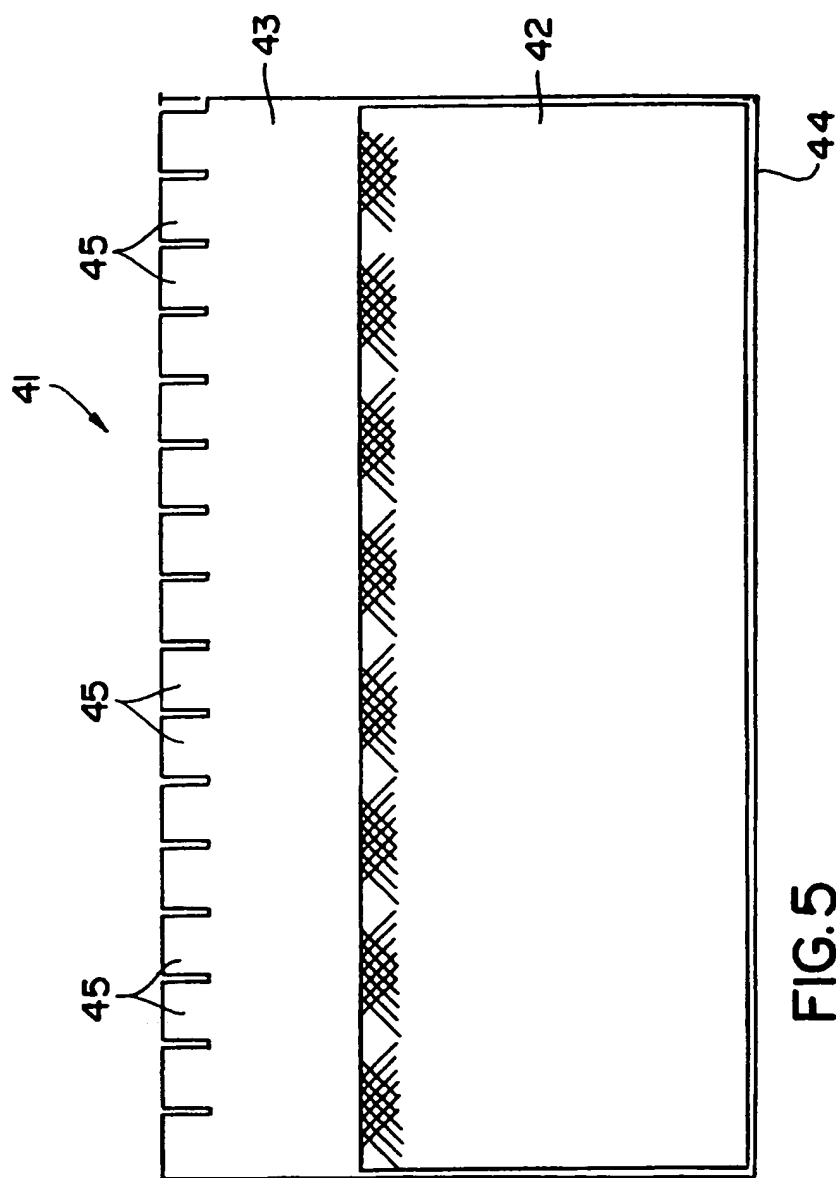
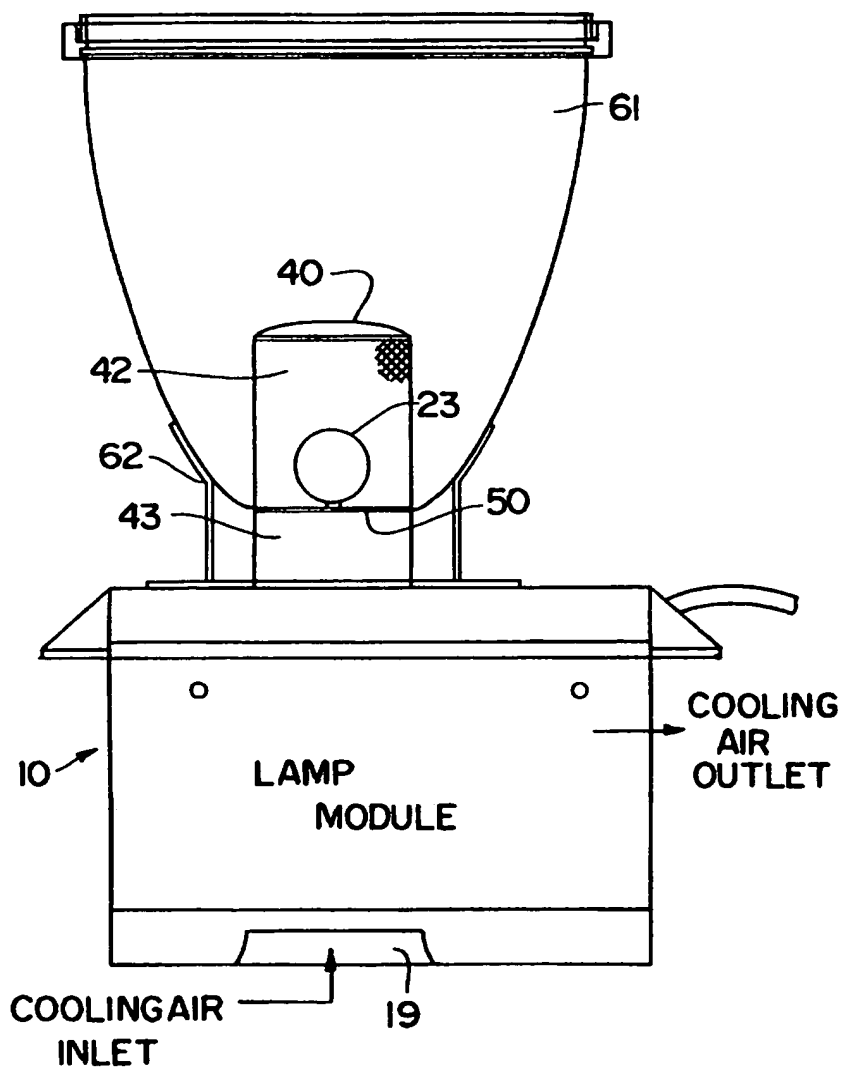


FIG. 5

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FIG. 6



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/18562

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :H01J 65/04

US CL :315/39, 248, 344; 359/847

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 315/39, 248, 344; 359/847; 313/113; 362/396, 341, 343

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5,334,913 (URY ET AL) 02 August 1994, see the sole figure & the detail description (in particular col 3, ls 8-20 & col 4, ls 10-24).	1,2,8,9
A	US, A, 2,733,637 (JOSEPH) 07 February 1956, see fig. 1 & col 2, ls 4-23.	1,8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

05 MARCH 1997

Date of mailing of the international search report

19 MAR 1997

Name and mailing address of the ISA/US  
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